THE UPCOMING CHALLENGE: TRANSBOUNDARY MANAGEMENT OF THE HYDRAULIC CYCLE

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Abstract. The increase in population and subsequent demand for food will lead to rising demand for water. These, in turn, will lead to increasing utilization of transboundary water resources. In the past treaties have focused primarily on the utilization of freshwater surface resources, in particular rivers. Most of the treaties dealt only with water abstractions and, in some cases, with in-stream uses, mainly navigation and hydro-electricity. However, a hydraulic cycle view suggests that *transboundary* water resources include not only freshwater flows, but also return flows (direct or as effluents), lakes and reservoirs, aquifers, and precipitation. Moreover, water quality changes along the cycle, and effects the potential and cost of utilization. As water resources would have to accommodate increasing and diversifying demand, better management of all parts of the hydraulic cycle would be needed. This paper argues that as a result of these observations, and the increasing tendency toward decentralization of authority and in some areas separatist trends, this century would be marked by a need to establish increasingly intricate transboundary management structures, that would address all facets of the hydraulic cycle. This argument is demonstrated for the Israeli-Arab case.

Keywords: groundwater, international water, Israeli-Arab water, wastewater, water management institutions

1. Introduction

The appropriation of water resources for human use is growing rapidly. Between 1950 and 1990 alone water use worldwide more than doubled, from approximately 1400 km^3 to some 3000 km^3 (Raskin *et al.*, 1996). This amount accounts for only 8% of the average annual runoff. However, due to the vast spatial and temporal discrepancies between availability of runoff and human demand patterns, many regions already utilize most of the readily available runoff. As a result, in many of these areas there is increasing competition over water. Such competition is made ever keener by the apparent deterioration in water quality and the growing realization of the environmental importance of in-stream use. As projections for this century suggest that these trends will continue, we can expect in this century (and millennium - if the trends are not reversed) that the extent of stressed freshwater resources would continue to rise. To address such stress, an increasing array of tools would have to be used (Postel, 1992).

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Water resources do not conform to administrative and political boundaries. In 1978 the Centre for Natural Resources Energy and Transport identified 214 international river and lake basins, 48 more than it identified 20 years previously. Biswas (1993a) argues that this often-quoted number is probably an undercount, as it is based in part on maps at a small scale, does not account for groundwater flows, is derived by an approach that suffers from several technical limitations, its definitions of what constitutes an international basin do not necessarily reflect the area that may be most important from a management perspective, and the data on which it is based is dated. In particular, it does not account for the many new countries that have been established since, particularly in eastern Europe. Boundaries complicate the management of resources, as they create discrepancies between spheres of control and natural systems. The likelihood that stressed international water bodies would be degraded may be greater, therefore, than intra-national resources.

As the demand for water increases, additional resources are appropriated. The result of such increasing utilization is in many cases reduced availability of freshwater to downstream and in-stream uses and users, and detrimental effects on the quality of the water remaining for other users. Moreover, as the demand for water increases and the local, exclusively national, sources are fully developed, it is likely that the main resources that would be further developed would be international in character (Biswas, 1993b). If this is indeed the case such development may cause international tensions and conflict to arise among the different users (be they riparian or not). It may also lead to the degradation of such resources, if cross-boundary management regimes are not agreed upon and implemented.

The potential conflicts regarding transboundary water resources have led to the signing of a large number of treaties. Wolf (1998a) notes that approximately 300 treaties have been signed since 1814 that deal with non-navigational issues of water management, flood control, hydropower projects, and allocations for consumptive and or nonconsumptive uses in international basins. Almost all of the 145 treaties he analyzed dealt with river systems. Only few international treaties address water quality issues (Shmueli, 1999). Yet, the history of human development is replete with the story of deterioration of water resources, that are aggravated as numbers rise (Ponting, 1992). Past treaties are unlikely therefore to address future issues comprehensively.

Terrestrial water, which is the focus of most studies, discussions, disagreements and agreements, is but one part of the great hydrological cycle, from the oceans to the atmosphere to the land and back again. Actually, in any given time freshwater resources are but a few percent of the total water resources. Moreover, of the total freshwater resources, almost two thirds are locked in glaciers and permanent snow cover, and are thus not included in the conventional water discourse. As a result, the options for utilizing additional parts of the hydraulic cycle are receiving increasing attention.

This paper suggests that if current trends continue (and there is no indication at this point that they would not) this century (and perhaps millennium) would be marked by the increasing need to address the international character of water flows, and the fact that all water flows are part of the great hydrological cycle. The management of water resources within this context would require more complex management structures. This argument is advanced by focusing on the Israeli-Arab case, as this region is one of the most water-stressed (using the water per capita based indices), and hence faces issues related to water scarcity somewhat earlier than more water abundant regions.

2. Human Interventions in the Hydraulic Cycle

The hydraulic cycle is described usually as a natural sequence through which water passes, including all the physical states - gaseous, liquid and solid - as well as the transformations among these states (for example, evaporation, precipitation, freezing and melting). In this cycle, described by the solid arrows in Figure 1, water passes from the atmosphere to oceans and terrestrial systems. In the terrestrial systems water flows between the surface, soil and aquifers.

Humans have intervened in the hydraulic cycle since the transition to agriculture in the Neolithic era, when farmers began to divert some of the flowing water for irrigation. During the last millennium these interventions have grown increasingly sophisticated, widespread, and larger in scale (the broken arrows in Figure 1).

The most widespread human intervention is in surface flows, often through the construction of dams. The reservoirs behind such dams often serve a myriad of uses - such as irrigation, power generation, flood control, municipal supply, groundwater recharge and recreation. By changing water flow patterns, dams affect ecosystems, alter groundwater and surface water regimes, change land use in wide areas and affect the local micro-climate. Canals and pipelines divert surface water from their channels and, in some cases, out of their natural drainage basins to distant urban or agricultural use. The extraction of surface water, particularly for irrigation, affects the extent of evaporation and hence the quantity and quality of the water remaining in rivers and lakes.

Human intervention is not limited any longer to surface flows. In many parts of the world groundwater is increasingly the main source of water. Abstractions

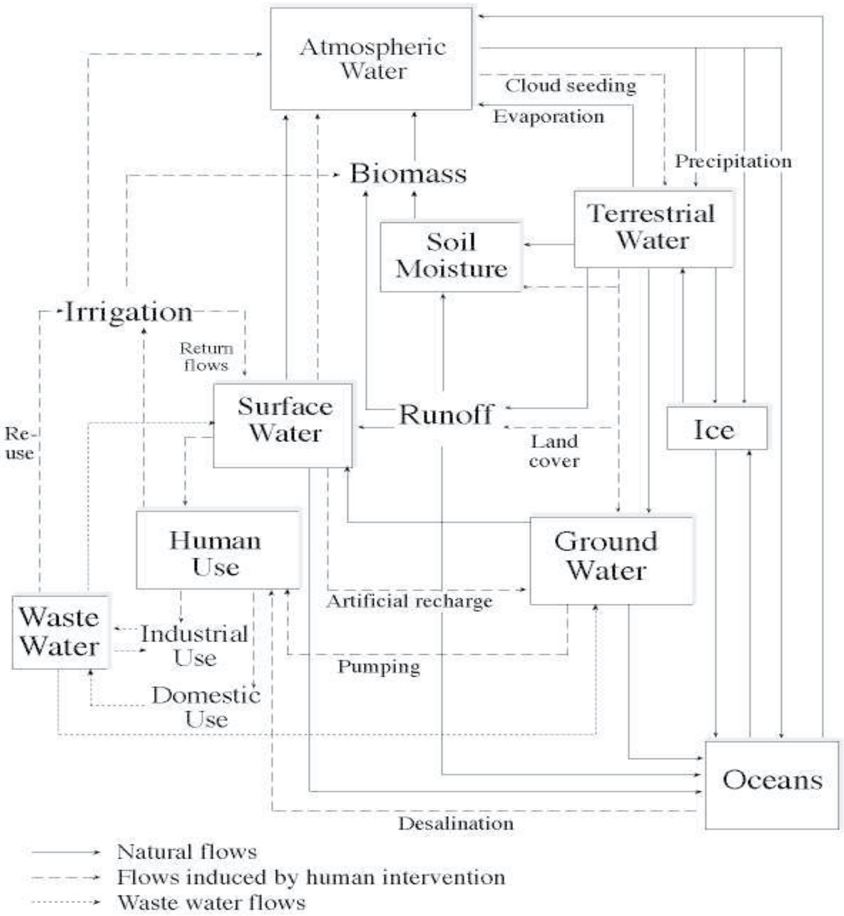

Figure 1: Human Interventions in the Hydraulic Cycle

from groundwater affect water levels in the aquifers, and subsequently spring discharge and the probability of salinization. Water levels and quality in the aquifers are also affected by land use and development patterns. Rising urbanization combined with increasing decentralization within metropolitan areas, rising levels of motorization and subsequent increase in roads, parking facilities and other ancillary transport services, increase the extent of impervious areas - affecting the amount of runoff and recharge. Increasing amounts of wastewater, solid waste and hazardous materials may also affect the quality of water percolating down to the aquifer. In recent decades humans also affect atmospheric water. Clouds are seeded to produce rain or divert storms. Long-range air pollution acidifies precipitation, and subsequently lakes and rivers.

Today, the scale of human intervention is such that in many parts of the world a significant percentage of terrestrial water flows in and out of human use (Raskin *et al*., 1996). These amounts can be enhanced by desalinization of sea water, and are reduced by increased evaporation. Human use, and particularly domestic and industrial usage, affects water quality. As a result the water emanating from such uses is termed wastewater, water that is not suitable for other uses without treatment. Therefore, in Figure 1, a third set of flows, wastewater flows, is added to the flows induced by human intervention. Wastewater often flows into rivers and lakes or percolates down to the aquifers, thereby polluting surface and groundwater resources. Wastewater can also be re-used beneficially, mostly for irrigation, after appropriate treatment. In other words, in an increasing number of cases, wastewater can be seen as a potential resource and not merely as a hazard.

Humans have devised many ways to manage common pool resources, such as water (Ostrom, 1990). However, most of the structures created for this purpose have been at the local level, and dealt with situations that are less stressful than those that arise today or are likely to arise in the future. As the scale of human intervention in the hydraulic cycle increases so does the likelihood that they cross some boundary. This has been recognized by a few international lawyers (Teclaff, 1991a). However, most of these interventions have not been addressed in international law, or in the treaties regarding water issues signed between different countries. Moreover, several important points of interaction, such as estuaries, have not received adequate attention in the international law literature (Hayton, 1991). Overall, international law has focused on the allocation of water, and has not provided an appropriate base for cooperation, or for a holistic managerial view of the hydraulic cycle, or even of basins (Benvenisti, 1996; Teclaff, 1991b). Yet, if the current trends continue these will have to be addressed in the future. To understand the need, complexity and options we turn now to the Israeli-Arab case.

3. Cross-Boundary Water Issues Between Israel and her Neighbors

The Middle East is considered the most water-stressed region of the world, with probably the lowest water availability per capita, and highest use per resource ratio (Raskin *et al*., 1996)[1]. Moreover, Raskin *et al* (1996) show that under conventional development scenarios conditions the use to resource ratio is likely to rise significantly within the next generation (from 58% in 1990 to 75% in 2025 and 94% in 2050). Within the Middle East, Israel, Jordan and the Palestinians seemingly face the most difficult situation, as they are supplied by

[1] Use to resource ratio is the ratio between average annual use and average natural long-term (past) recharge or flows.

already depleted fully utilized sources. Moreover, most of these sources, in particular the Jordan River and its tributaries and the Mountain Aquifers are shared by more than one entity. As a result the allocation and management of these resources has received significant attention in the literature (for example, Kliot, 1994; Wolf, 1993).

The actual interactions between the parties in this region are, however, more intricate than suggested in most studies. They include most of the human interventions in the water cycle identified in Figure 1. In this section these interactions are briefly reviewed, in order to identify some of the management issues they raise.

3.1. THE JORDAN RIVER AND ITS TRIBUTARIES

The Jordan River basin is currently shared by Israel, Jordan, Lebanon, Syria as well as the Palestinians. The allocation of water in the Jordan basin has been the focus of contention, discussions and negotiation since the early fifties (Lowi, 1993; Shuval, 1998). The upper Jordan River supplies approximately a third of Israel's annual water use, and is the source for Israel's National Water Carrier conveying water to the south (see Figure 2). The Yarmouk River is the principal source of supply to the densely populated parts of Jordan and through the East Ghore Canal to the Jordan Valley. The Syrians have dammed some of the Yarmouk's tributaries as part of a large-scale irrigation development effort in southern Syria. The Palestinians lay claim to 200 MCM of the 700 MCM that Israel abstracts from the Jordan's basin (Soffer, 1994).

Water allocations were the topic of Article 6 in the 1994 Israeli-Jordanian Peace Treaty. In this treaty the two sides did not opt for the seemingly straightforward separation option (as was done in the Indus case), whereby each receives the water of several tributaries and manages it as it sees fit. Rather, in addition to augmenting Jordan's water supply, Israel agreed to provide Jordan with *de facto* storage services for 20MCM. The parties also agreed to desalinate the saline water diverted from Lake Kinneret (Sea of Galilee), of which Jordan is to receive 50% (10 MCM). In addition, the agreement allows Israel to continue utilization of an aquifer in the Arava Valley, and establishes a management framework.

This recent agreement addresses, therefore, the joint development of future resources, as well as a series of issues beyond the straightforward division of surface flows. It does not specify, however, any measures for coping with drought situations, something that proved a source of contention during the last year (1998-9), which had an extremely dry winter, and does not show real concern for the ecological and environmental implications of water abstractions for the lower Jordan River and the Dead Sea. This agreement also does not address the Syrian, Lebanese and Palestinian claims. These will need to be addressed in future negotiations (Shuval, 1998).

3.2. THE MOUNTAIN AQUIFERS

Israel shares with her neighbors several aquifers. These are the Mountain Aquifers underlying the West Bank and Israel, the Arava Aquifer, the Hermon Aquifer feeding the Jordan River and the Gaza aquifer (Gross & Soffer, 1996). So far agreements have been reached with regard to the Arava and Gaza aquifers. The most important of the shared aquifers, however, are the Mountain Aquifers. These aquifers, shown in Figure 2, are the highest quality storage within Israel's water system, and the sole source of water for Palestinians on the West Bank. They include three major sub-basins. The western and northeastern aquifers are fully utilized, mostly by Israel. In the Oslo B accords, signed in

Figure 2: The Hydraulic Interactions between Israel and her Neighbors

September 1995, Israel agreed to a small increase in Palestinian use of the northeastern aquifer, and to substantial development of new sources in the eastern aquifer.

These karstic, limestone aquifers are susceptible to pollution, and to salinization from subterranean saline water bodies, if they are over pumped. Therefore, it has been long recognized that they should be managed judiciously, and that pumping from them should be controlled. Such restrictions were imposed by Israel during its period of absolute control over the whole three sub-aquifers (1967-1995). The introduction of boundaries between Israel and the Palestinian entity above these aquifers presents new challenges, as neither party can manage the aquifer alone and yet maintain its quality (and hence storage capacity). Therefore some level of joint management is necessary (Feitelson, 1996). This was realized in the Oslo B accords, where a coordinated management structure, including a Joint Water Committee and Joint Supervision and Enforcement Teams, were established.

The joint (or coordinated) management of shared aquifers requires that multiple issues be addressed (Feitelson *et al.*, forthcoming). These include protection of the aquifer by control of land use, wastewater recycling, and waste disposal sites and methods, control of pumpage, monitoring of water levels and quality, data collection, enforcement of restrictions, settlement of disputes regarding extraction or land use implications, adjustments of pumpage to variations in natural recharge and the establishment of appropriate institutional and legal structures to carry out the various tasks. As a result of the complexity of these tasks, and the usually false perception that water in the aquifers does not flow (and hence does not cross borders), there has been only scant experience with transboundary management of shared aquifers.

Since 1993 an Israeli-Palestinian team has been working to identify options for joint management of shared aquifers, and tailoring these options for the Israeli-Palestinian case. This team has advanced five basic options, each of which can be developed over time (Feitelson & Haddad, 1998). These options vary according to their goals and basic rationale. Consequently, they differ in terms of the actions they would undertake and the sequencing of the actions. However, the implementation of any such structure is fraught with pitfalls, all of which have to be addressed if any successful structure is to be established (Haddad *et al*., 1999). The range of issues that has to be addressed as part of any effort to manage shared aquifers in a sustainable manner ranges, therefore, far beyond the questions of sustainable yield, as manifested in abstraction and recharge rates.

3.3. ENHANCEMENT PROJECTS

The supply of water in any given region can be enhanced in a wide variety of ways. Allan (1994) has shown, for example, that the Middle East has been able to support its burgeoning population through the import of 'virtual water' in the form of food and agricultural products. However, there are additional options, many of which have been tried or discussed within the Israeli-Arab context.

3.3.1. Water Transfers

Israel has been conducting large scale inter-basin water transfers since the mid-fifties. As can be seen in Figure 2, Israel has built over the years a national water distribution system as an integrated grid, that also augments supply to parts of the West Bank and the Gaza Strip. Following the Israel-Jordan peace treaty, initial connections between the Israeli and Jordanian system have also been executed. One problem that emerged in the discussion of such transfers between Israel and her neighbors is the allocation of capital and operating cost for ongoing transfers as well as compensation for past investments.

In addition to these connections, enabling water transfers among different parts of Israel, and between it and her immediate neighbors, there have been several proposals to bring in additional water from further afield. In particular, there have been suggestions for transporting water from Turkey, Lebanon and the Nile (Shuval, 1992). While none of these has advanced beyond the conceptual stage, they are indicative of possibilities for transboundary water transfers that can help redress the spatial discrepancy between demand and supply patterns, and the acute scarcity in Israel, Jordan and Palestine.

3.3.2. Cloud Seeding

Cloud seeding to enhance rainfall has been attempted in Israel since the early seventies. Studies of the effect of this effort have indicated an increase of 5-15% in rainfall. However, these results have been disputed. Unsubstantiated evidence suggests that the seeding also had a beneficial effect in Jordan, and perhaps Syria. The lack of sufficiently clear evidence of beneficial effects within Israel, and budget cuts in the last few years have resulted in practical termination of this effort. Regardless, this effort indicates some of the difficulties inherent in positive sum efforts that have a stochastic cross-border effect. Specifically, there is a disincentive to invest in such efforts, as the party that invests in the effort cannot be assured of reaping all the benefits. Consequently, efforts that may have a positive regional effect may be under-funded, or terminated, because of lack of support in the intra-national budget allocation.

3.3.3. Flood Control and Artificial Recharge

Other efforts that may have positive stochastic transboundary effects are flood control and artificial recharge schemes. These schemes usually involve damming of tributaries. A small number of such schemes were built within Israel. Recently, a proposal for such a scheme on the West Bank has been studied. This scheme suggested that winter flows affecting the Tel Aviv metropolitan area be captured upstream, within the West Bank, and recharged into the Mountain Aquifer. In a cross-boundary setting, such schemes face particular problems, as the loss of land, cost and maintenance would be borne in the West Bank, while the flood mitigation benefits would be felt downstream within Israel, and the distribution of recharge benefits would be a function of the allocation of the water of the specific wells positively affected by the additional recharge. Moreover, pollution issues during recharge could lead to cross-border pollution problems.

3.3.4. Desalination

Large scale desalination was first proposed in Israel by the U.S. in the mid-sixties. However, it was found to be too costly at the time. Following the massive immigration wave of the early nineties (when over 800,000 new immigrants poured into the country within eight years) and rapid economic growth in the early nineties, sea water desalination was proposed again in the nineties as a major element in Israel's water future. This proposal has been incorporated into the Israeli long term plans (Schwartz, 1996).

As water stress in the land-locked West Bank and in Jordan is expected to worsen, it is possible to augment water supply to those areas from desalination plants sited along Israel's Mediterranean coast[2]. Clearly, any such scheme would have to be part of an agreement between the partners. The major issue in any desalination project are its costs. As most of Israel's major population centers lie along the Mediterranean, desalination plants can therefore supply water at relatively lower cost. In contrast, supply to the West Bank or Jordan would require significant additional pumping costs. Such cost may undermine this option. Therefore, it is possible that desalination would be a feasible regional input only within a more comprehensive management plan, whereby Israel would provide the Palestinians and/or Jordanians with cheaper water, possibly supported by donors, and substitute them with desalinated water, thus reducing the overall cost of provision for all parties. Naturally, implementation of such a comprehensive scheme would require a much more complex financial, institutional and accounting framework. One possibility for addressing these issues is the establishment of a regional water market. However, water trading will lead to higher, real water prices, hence encouraging conservation and substitution away from irrigation, and thus is likely to delay the need for desalination (Arlosoroff, 1997).

[2] Alternatively, inland sites drawing sea water from the Mediterranean can be conceived, or plants can be sited in the Palestinian Gaza Strip, and the water produced be transported across Israel. For this paper the important point that in all the options Israel would have to be a party, as at the very least water to or from the desalination plants would have to traverse its territory.

3.3.5. Water Conservation and Demand Management

The least obvious, but perhaps the most readily available way to enhance water availability is water conservation and demand management. Israel has been famous for its success in increasing the product of water in irrigation through water conservation, primarily drip irrigation. Still, Israel can achieve much greater saving if demand management and water conservation in the urban sector would be implemented. Water conservation also holds much promise in Jordan, where urban water losses are significant.

Clearly, these methods should be implemented within each country, and thus do not have an obvious cross-boundary aspect. However, as the emphasis in many of the water negotiations is on need (see Wolf, 1998b), and the ability to address needs can be affected by the extent to which these measures are implemented, they have an indirect effect on international water negotiations. In the Israeli-Arab context these measures were raised as part of the multi-lateral negotiation track.

3.4. WASTEWATER MANAGEMENT AND RE-USE

Wastewater is both a potential source of pollution, threatening water quality in the major reservoirs and streams, and the cheapest significant source for additional water for irrigation. In Israel most of the coastal steams are currently polluted by wastewater. Concurrently, wastewater has been extensively used for irrigation, mainly of industrial crops. Since 1990 a major effort was undertaken in Israel to upgrade existing treatment plants and build new ones. As a result, it is expected that the quality of wastewater available for re-use will improve within the next few years. One of the possible uses for part of the recycled water according to current plans is the rehabilitation of coastal streams.

No secondary wastewater treatment plants have been built on the West Bank until recently. As most of the population centers in the West Bank are situated above the Mountain Aquifers' recharge areas, the sewage flows threaten the shared resource. Moreover, in several locations, sewage flows will cross the boundaries between Israel and the nascent Palestinian entity, regardless of the final delineation of these boundaries. The main points where such flows cross boundaries are near the towns of Jenin, Tul Karem and Qalkilia, and in the Jerusalem metropolitan region.

The sewage of Tul Karem pollutes the Alexander stream that runs through the Emek Hefer regional council to the sea. A plan has been prepared for rehabilitating this stream by using recycled water. Subsequently, the regional council has reached an agreement with the city of Tul Karem (situated in the West Bank) whereby it would assist in the building and maintenance of an internationally funded treatment plant for Tul Karem's wastewater, and would re-use the wastewater that cannot be re-used by the Palestinians. While this agreement has not been implemented yet, it is indicative of the potential for local level agreements regarding both the treatment of cross-boundary effluents, and the re-use of the recycled water.

The Jerusalem metropolitan region is comprised of an intricate web of Israeli and Palestinian settlements and neighborhoods. It is the only metropolitan area in Israel not served by a secondary level treatment plant, until 1999. As it sits astride the main water divide between the Mediterranean and the Dead Sea, and several sub-basins, all current plans suggest that the metropolitan area's wastewater should be treated in several plants. Today three plants are planned to treat the wastewater of Jerusalem and the Bethlehem area. In a study of the management possibilities in such a cross-order situation total separation, coordination, comprehensive metropolitan management and privatization options were compared. The analysis of these options suggested that privatization of the treatment systems may have a special advantage in a cross-boundary situation, as it may help de-politicize the wastewater issue. Moreover, the two sides have to work together in order to obtain the best deal from a third party, often a multi-national firm (Feitelson, and Abdul-Jaber, 1997).

The study of Jerusalem's wastewater treatment options identified enforcement, financing, flexibility and accountability issues as key variables for addressing transboundary sewage flows. This study did not analyze, however, the re-use options of the treated wastewater. One option for integrating the wastewater and transborder aquifer management issues was raised as part of the previously noted joint management of shared aquifers study. Essentially, a freshwater for recycled water trading option was proposed, whereby Palestinians would receive additional freshwater for domestic use, contingent upon the return of a pre-specified percentage as recycled water at an agreed upon quality level (Feitelson, 1998). This option, as well as the Emek Hefer-Tul Karem case, highlights the importance of integrating return flow quality considerations, financing and distribution issues in agreements regarding transboundary water resources.

4. Discussion: A New Transboundary Management Agenda

The Israeli-Arab case reflects worldwide trends in water issues, and provides insights regarding the unfolding agenda for the future. As in other parts of the world, the agenda initially focused on the use of surface water, primarily its allocation among the riparian states. This agenda has only recently been widened to include groundwater abstraction and quality. Still, the issues addressed under the current agenda are unlikely to reflect the full scope of issues that would have to be addressed in the future. This can be seen in all facets of the Israeli-Arab case.

In the case of the Jordan River, inadequate attention was given to the environmental and ecological importance of in-stream use, or to the possibilities for rehabilitating the river. These issues are already receiving some attention in the international water scene (Teckalf & Teckalf, 1994). An important feature in the Israeli-Jordanian treaty is the provision of storage services by Israel to Jordan. Such services are of particular importance in a semi - arid climate. Management of such services may well be part of the future agenda, especially if the reservoir itself is shared. In this case innovative approaches to the management of water storage may be called for, such as the capacity sharing approach advanced by Dudley and Musgrave (1988). Other elements in the water cycle that did not receive sufficient attention in past or current agreements are return flows and their implications for water quality. Yet, return flows are central to the management of rivers in many parts of the world. They should be, therefore, an integral part of future treaties.

The description of the water related interactions between the parties in the Israeli-Arab case shows that the extent of interactions among the parties is much wider than the question of the allocation of surface water. Actually, the allocation of the Jordan River's water is the only issue already addressed in a peace treaty between two major riparians. Therefore, it can be expected that the focus of discussion in future negotiations would gradually shift to other elements of the water cycle, most notably groundwater, water quality and wastewater issues. Yet, as the discussion of the Israeli-Arab context suggests, these issues cannot be addressed alone. Any coordinated or joint management structure for shared aquifers requires that a wide array of issues would be addressed as part of the joint management agreement (Haddad *et al*., 1999). Moreover, the more advanced the level of management the more elements that need to be addressed within such a structure. The same is true also for wastewater issues. In the Israeli-Palestinian case, for example, wastewater treatment issues are related to groundwater protection, water quality, water allocations, agricultural development, public health and stream rehabilitation. It is likely, therefore, that the future agenda would have to address a much wider set of issues, pertaining to more parts of the hydrological cycle than the current agenda does.

Surface water, groundwater and wastewater quantity and quality issues differ in the level at which they should be addressed. Transboundary surface water management often requires a basin-wide approach. Only at this scale can the best use of water be made to all concerned, the need for which would only increase. Aquifer basins often differ markedly from river basins. Moreover, their edges are not as easily discerned. Thus the determination of an appropriate spatial scale of management, and hence for transboundary agreements, is more difficult than in the case of surface water. Wastewater issues, in contrast, are determined by human actions. Yet, the scope is mostly local or regional. The methods used to analyze such situations have to be tailored accordingly (Haruvy, 1996). The implication of these observations is that management structures that address the multiplicity of factors, such as agreements pertaining to rivers fed by several aquifers along which there are many wastewater treatment plants, would have to be multi-layered. They would have to include different elements at different spatial scales, and in some cases imbed within them an array of local or regional agreements.

The brief discussions in the previous sections, and the studies on which they are based, suggest that not only should future agreements pertain to additional elements of the water cycle, but also that there are many issues that should be addressed but have not received adequate attention in previous Israeli-Arab negotiations, or in most international treaties signed to date. Consequently, the agenda of future international water treaties would be different than that faced by past generations. Table I compares the agenda of past treaties, as seen in the impressive data base compiled by Aaron Wolf with the issues of the new agenda.

TABLE I

The Current and Future International Water Agenda

Facet	Current Treaties	Future Agenda
Principal Focus	water supply; hydropower	water quality; return flows; pollution
Parts of Water Cycle Included	mainly rivers and lakes	surface water; groundwater; recycled water
Signatories	mostly bilateral	increasingly multilateral
Non Water Linkages	few, mostly related to money	many, including land use, waste management & money
Enforcement	rare (20% of treaties)	increasingly incorporated
Monitoring and Data Sharing	appears in over half of treaties	will appear in most agreements
Allocation Methods	simple ‘equitable’ one-time allocation of freshwater	multi-dimensional time sensitive allocations differentiated by quality levels

Source for current treaties: Hamner J. and Wolf A., Patterns in international water treaties: the transboundary freshwater dispute database, *Colorado Journal of International Environmental Law and Policy* 1997 Yearbook, cited in: Wolf (1998a).

The main differences between past treaties and the new agenda is likely to be in their principal focus. While past treaties focused primarily on water supply and hydropower the new agenda is likely to focus much more on water quality, resource management and wastewater issues. The new agenda will also address many parts of the water cycle hardly addressed before, in particular groundwater. The differences, however, are not likely to be limited to the principal issues to which the treaties pertain. The treaties of the next century are also likely to differ in terms of the measures and specifications they propose and the ancillary issues they address. For example, as more costly sources are tapped, issues of affordability are likely to become increasingly prominent, something that may result in greater emphasis being placed on financial issues.

The treaties may also be increasingly multilateral as the multiplicity of interactions and the full spatial ramifications are recognized.

One of the most important differences may be in the allocation principles of water. Wolf (1998b) has already noted a shift in international treaties from rights to need based allocations. When combined with the likely increase in prominence of affordability issues, this trend suggests that socio-economic considerations will become a more important consideration in water allocations than is the case today. Moreover, water allocations should not be limited to water quantities. Rather, an allocation should be specified by several parameters including the quality of water received and the quantity and quality of return flows to which the recipient is obliged, the timing of abstraction and discharge, the allowed use, priorities of abstractions and redlines for abstraction by use (Feitelson, 1998). These specifications would pertain to the wastewater part of the cycle as well. As competition over all parts of the cycle becomes keener and environmental awareness rises, it can be hoped that within the next century treaties would address these parameters.

One of the ancillary issues that has not been addressed in most treaties, but is likely to become increasingly important is the relations between land use development patterns, runoff and water quality. This relationship is well known. However, it was mostly discussed at the local, intra-national levels. Yet, the rising scale of development, growing concern over water quality and groundwater recharge may well force this issue into the international agenda as well.

5. Conclusions

Within this millennium, and probably even within this century, progressively larger parts of the world will face the water issues currently faced by Israel and her immediate neighbors. As a result it can be expected that the lessons of the Israeli-Arab case will serve as an important precedent to other regions. In particular, it seems that additional parts of the water cycle will be utilized in an ever wider set of circumstances. These will increasingly include transboundary situations.

The challenge that will be faced, therefore, is to establish management structures that will be able to address this progressively more complex situation. These management structures would by necessity be more complex than those established under current treaties. They would have to include new and innovative combinations of local, regional, national and supra-national bodies, incorporating both the public and private sectors as part of the management regimes. They would be manifest in an increasingly varied and complex set of institutional structures governing transboundary flows of different parts of the hydraulic cycle. These structures would have to address a wider set of issues than addressed under current transboundary regimes, as manifest in current treaties in force. In this paper a very tentative attempt was made to identify some elements of the new agenda that would have to be addressed by these institutions. However, it is more than likely that reality would be even more challenging than the set of issues raised herein.

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